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6. AUTHOR(S)

DR BURGER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

FISK UNIVERSITY
BUDGET AND GRANTS OFFICE
1000 17TH AVENUE N
NASHVILLE TN 37208

8. PERFORMING ORGANIZATION
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AFOSR/NE
4015 WILSON BLVD
SUITE 713
ARLINGTON VA 22203

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The goal of this program is to build a research infrastructure in the scientific area of optical characterization of advanced infrared materials under the sponsorship of the Air Force Office of Scientific Research and is directed towards areas of interest to the U.S. Air Force. The incorporation of a research grade UV-Vis-NIR spectrophotometer to be purchased under the proposed DURIP grant will establish an additional basic characterization capability to be applied in the investigation of materials for infrared optical parametric oscillators and mid-IR tunable lasers. The UV-Vis-NIR spectrophotometer proposed here will extend the spectroscopic range to include the 1-3.3 μ m range which is critical in the investigation of the properties and structure of II-VI compound crystals and other semiconductors. The new research grade instrument will enable us to investigate the absorption and other optical losses induced by deviations from stoichiometry as well as the absorptions induced by transition metal dopants to be evaluated as lasants. The approach will involve an investigation of the basic physical properties of advanced materials studied in the context of the various processes involved in the technology and the possibility of their implementation in useful devices through collaboration with AFRL scientists. Graduate student training is considered an integral part of this investigation. It is expected that the program will increase the involvement of science students, in particular minority and underrepresented groups, and motivate them to pursue careers in this important area of physics.

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Final Report on the DURIP project to acquire a:

UV-VIS-NIR Spectrometer for
Characterization of Advanced IR Materials

SUBMITTED TO: Major Daniel K. Johnstone, PhD
AFOSR/NE

801 N. Randolph Street
Arlington, VA 22203-1977
703 696-7545
fax 696-8481

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**FISK UNIVERSITY,
NASHVILLE, TENNESSEE 37208**

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Principal Investigator
Arnold Burger, Ph.D.
Phone: (615) 329-8516
FAX: (615) 329-8634

EXECUTIVE SUMMARY

The goal of this program is to build a research infrastructure in the scientific area of optical characterization of advanced infrared materials under the sponsorship of the Air Force Office of Scientific Research and is directed towards areas of interest to the U.S. Air Force. The incorporation of a research grade UV-Vis-NIR spectrophotometer to be purchased under the proposed DURIP grant will establish an additional basic characterization capability to be applied in the investigation of materials for infrared optical parametric oscillators and mid-IR tunable lasers. The UV-Vis-NIR spectrophotometer proposed here will extend the spectroscopic range to include the 1-3.3 μm range which is critical in the investigation of the properties and structure of II-VI compound crystals and other semiconductors. The new research grade instrument will enable us to investigate the absorption and other optical losses induced by deviations from stoichiometry as well as the absorptions induced by transition metal dopants to be evaluated as lasers. The approach will involve an investigation of the basic physical properties of advanced materials studied in the context of the various processes involved in the technology and the possibility of their implementation in useful devices through collaboration with AFRL scientists. Graduate student training is considered an integral part of this investigation. It is expected that the program will increase the involvement of science students, in particular minority and underrepresented groups, and motivate them to pursue careers in this important area of physics.

a) Objectives and Major Tasks

Researchers in the Fisk University Physics Department have been working in the area of crystal growth and crystal characterization of semiconductor for a number of years. The objective of this proposal is to build upon the Department's expertise in these areas by providing the instrumentation necessary to extend these studies and to enhance our capabilities in the area of optical characterization by UV-VIS-NIR spectroscopy. The optical crystals being developed at Fisk are of great importance for both optical and electronic devices for both civilian and military applications. We are presently involved in the study of silver gallium telluride for optical parametric oscillators (OPOs) and the development of a novel mid-IR laser based on Cr^{2+} :CdSe both of which as tunable infrared sources may find their practical use for IRCM's, active multispectral sensing and identification of biological and chemical agents.

The have benefited from the presence of the new equipment are:

- 1) "Growth And Characterization of Doped CdSSe and CdSeTe For Optoelectronic Applications", in partnership with AFRL/Wright Lab, Dr. Mel Ohmer is technical monitor
- 2) Preliminary studies of Cr^{2+} doped CdSe, a collaboration with Dr. Ken Schepler at AFRL/Wright Lab

The new instrumentation was useful in determining the morphological and compositional uniformity of crystals prepared in our laboratories that have useful infrared applications.

b) The Equipment and its Installation

After selecting three vendors we have decided on the purchase of a Cary 500 UV-VIS-NIR spectrophotometer. The cost of the instrument is \$83,659, and we have received a donation of \$8700.54 from the vendor

The specifications of the instrument are: The working range extend beyond 6 absorbance units, and a wavelength range covering the low UV, 175 nm, up to near infra red (NIR), 3300 nm. The spectrophotometer incorporates a PbS detector which is thermoelectrically cooled to 0 °C to reduce photometric noise. The wavelength accuracy is ± 0.1 nm, with wavelength reproducibility less than 0.025 nm. Accessories include diffuse and variable angle reflectance accessories and an extended sample compartment to accommodate a cryostat, for low temperature measurements. An estimated useful life for this type of equipment is around 30 years.

The instrument was installed on June 29, 1999. On August 18, 1999 the scientists and faculty has attended a training session by the Varian applications engineer.

c) New Air Force projects at Fisk benefiting from the new instrumentation.

The acquisition of the CARY 500 spectrophotometer with DURIP funds has significantly increased our research infrastructure at Fisk and we have been able to receive AFOSR funding to grow a new class of quaternary chalcopyrites (Dr. Joan Fuller, Ceramic and Non-Metallic Materials Program Manager Directorate of Aerospace and Materials Engineering provide the crystals grown in this component to the AFRL team collaborators, as well as AFRL and industrial affiliates for additional testing (IR mapping, determination of birefringence) and device fabrication. One important expected outcome of the project is to establish a scientific base and understand fundamental optical properties within the class of chalcopyrite materials. This should then be exploited by the crystal growth component of the proposal to develop improved materials to design successful strategies for doping, defect reduction and removal of undesirable impurities to lower levels than presently available. This in turn is the key to improving power performance of infrared laser conversion based on these materials. The crystals grown in this program were and will be made available for evaluation to our AFRL collaborators, Dr. Jonathan Goldstein, Nonlinear materials team, Materials Directorate, AFRL/MLPO/WPAFB, ph. (937)255-4588 ext 3239, e-mail: Jonathan.Goldstein@wpafb.af.mil and Dr. Shekhar Guha, AFRL/MLPJ/WPAFB, ph. (937) 255-0119 ext 3022 e-mail: Shekhar.Guha@wpafb.af.mil